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APPLICATION FOR LETTERS PATENT

for

RADIUSED LEADFRAME

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TITLE OF THE INVENTION

RADIUSED LEADFRAME

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of application Serial No. 09/004,214, filed January 9, 1998, pending.

BACKGROUND OF THE INVENTION

Field of the Invention: The present invention relates generally to integrated circuit semiconductor chips. More particularly, it pertains to leadframes for bonding with the integrated circuits.

Integrated circuit manufacturers face many design challenges, including reducing the amount of noise in the integrated circuit. Resistance, capacitance and inductance, parasitics of an integrated circuit package, can result in increased signal delays and signal distortions in the electrical signals transmitted to and from the integrated circuit.

Two sources of noise in an integrated circuit package are switching noise and crosscoupling noise, or crosstalk. Switching noise may be an inductive voltage spike that occurs on a conductive path as the result of rapid current switching in the conductive path. Crosstalk is the undesirable appearance of an electrical current in a conductive path as a result of mutual capacitance and inductance between the conductive path and other nearby conductive paths. At higher frequencies, the integrated circuit is even more susceptible to noise.

One approach to reduce noise in an integrated circuit is to increase spacing between transmission lines, such as leads of a leadframe 100 as shown in Figure 1. The individual leads 110 forming a right angle are curved in a small portion of the lead and have tightly radiused corners 118. However, as integrated circuits and electronic equipment become smaller and more complex, spacing transmission lines farther apart becomes increasingly difficult, if not impossible.

Another approach to reduce noise is to reduce the length of the transmission line on a leadframe by using diagonal leads. While diagonal leads minimize the length of the leads, the spacing between the leads would also be decreased. The decreased spacing would increase the overall crosstalk between the leads, and would therefore be undesirable.

Accordingly, there is a need for an integrated circuit package in which the above benefits are achieved and the above problems overcome.

BRIEF SUMMARY OF THE INVENTION

The present invention solves the above-mentioned needs in the art and other needs which will be understood by those skilled in the art upon reading and understanding the present specification.

A leadframe is provided comprising, in part, a first and second set of conductors. The leadframe is adapted for coupling with a semiconductor integrated circuit. The conductors of the leadframe extend radially from a first end to a second end such that a portion of each conductor has a generally arcuate shape between the first and second end. In one embodiment, the first end of the conductor is for coupling with a printed circuit board, and the second end is for coupling with a semiconductor die. Alternatively, each conductor is sized and spaced such that the line spacing remains constant.

In another embodiment, the conductors have a plurality of segments. Each conductor has at least three segments disposed between the first end and the second end. The segments forming the conductors are disposed such that a portion of each conductor generally has an arcuate shape. In another embodiment, the segments each have substantially the same length. Alternatively, the segments have varying lengths.

In one embodiment, an integrated circuit package is provided comprising a leadframe having a plurality of leads, at least one semiconductor die coupled with the plurality of leads, and an insulating enclosure encapsulating the die and a portion of the leadframe. The leads each extend radially from a first end to a second end such that a portion of each lead has a generally arcuate shape. Alternatively, in another embodiment, the leads each have at least three segments disposed between the first end and the second end.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 is a top plan view illustrating a conventional leadframe having leads with tightly radiused corners;

Figure 2 is a top plan view illustrating a leadframe constructed in accordance with one embodiment of the present invention;

Figure 3 is a top plan view illustrating a leadframe constructed in accordance with another embodiment of the present invention;

Figure 4 is a top plan view illustrating an integrated circuit package constructed in accordance with one embodiment of the present invention; and

Figure 5 is a top plan view illustrating a leadframe constructed in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the spirit and scope of the present invention. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

A portion of a leadframe 200 is illustrated in Figure 2. The leadframe 200 has first and second sets of leads 210, 215. Although leads are discussed, other conductors can be used, such as lead fingers, and are considered within the scope of the invention. The first set of leads 210 extends from a first end 220 to a second end 230, and the second set of leads 215 extends from the first end 220 to a third end 225. For the first set of leads 210, the first end 220 is substantially perpendicular to the second end 230. For the first and second set of leads 210, 215, the first end 220 is for electrically coupling with an electronic system, such as a printed circuit board. The

first end can be coupled using reflow solder and other methods as known by those skilled in the art. The second end 230 of the first set of leads 210 and the third end 225 of the second set of leads 215 are adapted for coupling with a semiconductor die, as will be discussed further below.

In one embodiment, a portion of each lead of the first set of leads 210 has a generally arcuate shape, as the lead 210 extends radially from the first end 220 to the second end 230. For some of the first set of leads 210, a substantial portion of the lead has a generally arcuate shape. The arcuate shape of each lead of the first set of leads 210 has a different arc length than the other leads of the first set of leads 210. In another embodiment, each lead of the first set of leads 210 is spaced and sized such that the line spacing between at least one lead, or alternatively each lead, remains constant from the first end 220 to the second end 230. Each lead of the second set of leads 215 extends substantially straight from the first end 220 to the third end 225.

Another embodiment is illustrated in Figure 3. A leadframe 300 has first and second sets of leads 310, 315. The first set of leads 310 extends from a first end 320 to a second end 330, and the second set of leads 315 extends from the first end 320 to a third end 325. In one embodiment, the first end 320 of each lead of the first set of leads 310 is substantially perpendicular to the second end 330. For both the first and second sets of leads 310, 315, the first end 320 of each lead is for electrically coupling with a printed circuit board. The second end 330 of the first set of leads 310 and the third end 325 of the second set of leads 315 are adapted for coupling with a semiconductor die, as will be discussed further below.

In one embodiment, each lead of the first set of leads 310 has at least three segments 340. The segments 340 are disposed such that a portion of each lead of the first set of leads 310 has a generally arcuate shape between the first end 320 and the second end 330. The arcuate shape of each lead of the first set of leads 310 has a different arc length than the other leads of the first set of leads 310. The segments 340 are substantially straight, and are each substantially the same length and substantially the same width. In one embodiment, at least one of the segments 340 is substantially straight and has a different length. In another embodiment, at least one of the segments 340 has an arcuate shape as shown in Figure 5. Each lead of the second set of leads 315 extends substantially straight from the first end 320 to the third end 325. The segmented

leads provide a significant advantage since they are stamped, which is easier and less expensive to manufacture.

The leadframe 200 of Figure 2 and the leadframe 300 of Figure 3 are formed from a single sheet of material or thin strip which is etched or stamped into a predetermined shape for connection with a selected chip design. The leads off the die are substantially flat. However, the leads or sections of the leadframe that extend over the die may need to be upset or downset, depending upon where the parting line of the mold is formed. After encapsulation in plastic, portions of the leadframe extend out of the respective chip packages. In one embodiment, the leadframe extends out of the sides of the packages at a selected elevation which is determined in advance. These outwardly extending portions include the ends of the leads of a package. These leads may be ultimately bent for insertion into a suitable connector device.

As shown in Figure 4, a leadframe 400 is assembled into an integrated circuit package 405. A semiconductor die 460 comprises circuitry (not shown) formed centrally on the die 460 and a plurality of bond pads 465 formed around the periphery of the die 460. The semiconductor die 460 is mounted using LOC technology with additional support from the leadframe at the edge of the die opposite the bond pad (not shown). Electrically conductive wire bonding 480 is used to connect selected bond pads 465 on the die 460 to selected leads of the leadframe 400. A portion of each lead of the first set of leads 410 of the leadframe 400 is formed in a generally arcuate shape. In one embodiment, a portion of the first set of leads 410 extends radially from a first end 420 to a second end 430. Alternatively, the first set of leads 410 includes a plurality of segments for forming the arcuate shape.

In one embodiment, the leadframe 400, semiconductor die 460 and wire bonding 480 are enclosed in protective, electrically insulative material such that ends of the leads are exposed to allow connection to be made to other electrical components. In another embodiment, leadframe 400, semiconductor die 460 and wire bonding 480 are encapsulated in plastic, thereby forming the integrated circuit package 405.

An integrated circuit package including the leadframe according to the invention has reduced effective inductance and crosstalk relative to existing integrated circuit packages. Below are simulated inductances and resistances for the tightly radiused leads of the conventional right

angle leadframe shown in Figure 1 and the leads of the arcuate leadframe shown in Figure 2. The lead number refers to leads shown in figures 1 and 2. Like numbers in the figures indicate leads connecting between same locations on the die and same exterior connections.

TABLE 1

Lead No.	Prior Art Lead Figure 1 (nH Ohms)	Radiused Lead Figure 2 (nH Ohms)
1	10.30 .514	9.62 .452
2	9.38 .522	8.85 .466
3	8.71 .506	8.29 .451
4	8.08 .476	7.83 .432
5	7.32 .423	7.39 .409

The results in Table 1 reveal the decreased inductance for the present invention. The inductance and resistance of each lead is less for the arcuate leadframe and the segmented leadframe than in the tightly radiused leadframe. In particular, the longer leads experience the greatest improvement in using the arcuate leadframe and the segmented leadframe versus the tightly radiused leadframe.

Advantageously, the radiused leadframe provides for lower inductance, resistance, and capacitance of leads in a leadframe, as opposed to leads with tightly radiused corners. These factors are important when the leads are carrying high-frequency signals; or signals having high-frequency harmonics, such as sub-nanosecond rise times. The continuous arcuate shape of the leads and the constant width of the leads maintains line spacing between the leads. This consistency maximizes layout space of the leadframe without increasing crosstalk. In addition,

a single leadframe strip or assembly can comprise leadframes for any number of a predetermined number of chips.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000